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SOLAR/1014-79/04

Monthly Performance Report

HEI WAI WONG

APRIL 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT

HEI WAI WONG

APRIL 1979

I. SYSTEM DESCRIPTION

The Hei Wai Wong site is a four-story multifamily housing complex in Honolulu, Hawaii. Solar energy is used for preheating domestic hot water (DHW) and laundry service hot water. The solar energy system comprises three distinct, essentially identical systems, only one of which is instrumented for performance evaluation. The instrumented system supplies preheated hot water to six apartment units and to the laundry of the housing complex. The system has an array of flat-plate collectors with a gross area of 807 square feet. The array faces south at an angle of 24 degrees to the horizontal. Water is the transfer medium that delivers solar energy from the collector array to storage and to the hot water loads. Solar energy is stored on the roof in a 1230-gallon storage tank. When solar energy is insufficient to satisfy the hot water loads, auxiliary water heating for each apartment is provided by electrical heating elements in individual 30-gallon DHW tanks. Auxiliary heating of hot water in the laundry is provided by a gas heater in the 85-gallon hot water tank. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when a sufficient temperature difference exists between the collector surface temperature and the bottom of storage to activate a thermosiphon flow between collector and storage. The flow continues as long as the temperature difference is great enough to maintain the effect.

Mode 2 - Storage-to-Load: This mode activates when there is a demand for hot water replenishment from either the individual DHW tanks or the laundry tank. The system is pressurized by the city water system.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied in April and the solar energy system operated continuously during the month. Solar energy satisfied 94 percent of the DHW requirements. The solar energy system provided electrical energy savings of 8.6 million Btu and a fossil fuel energy savings of 4.5 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 46.9 million Btu for a daily average of 1935 Btu per square foot. This was

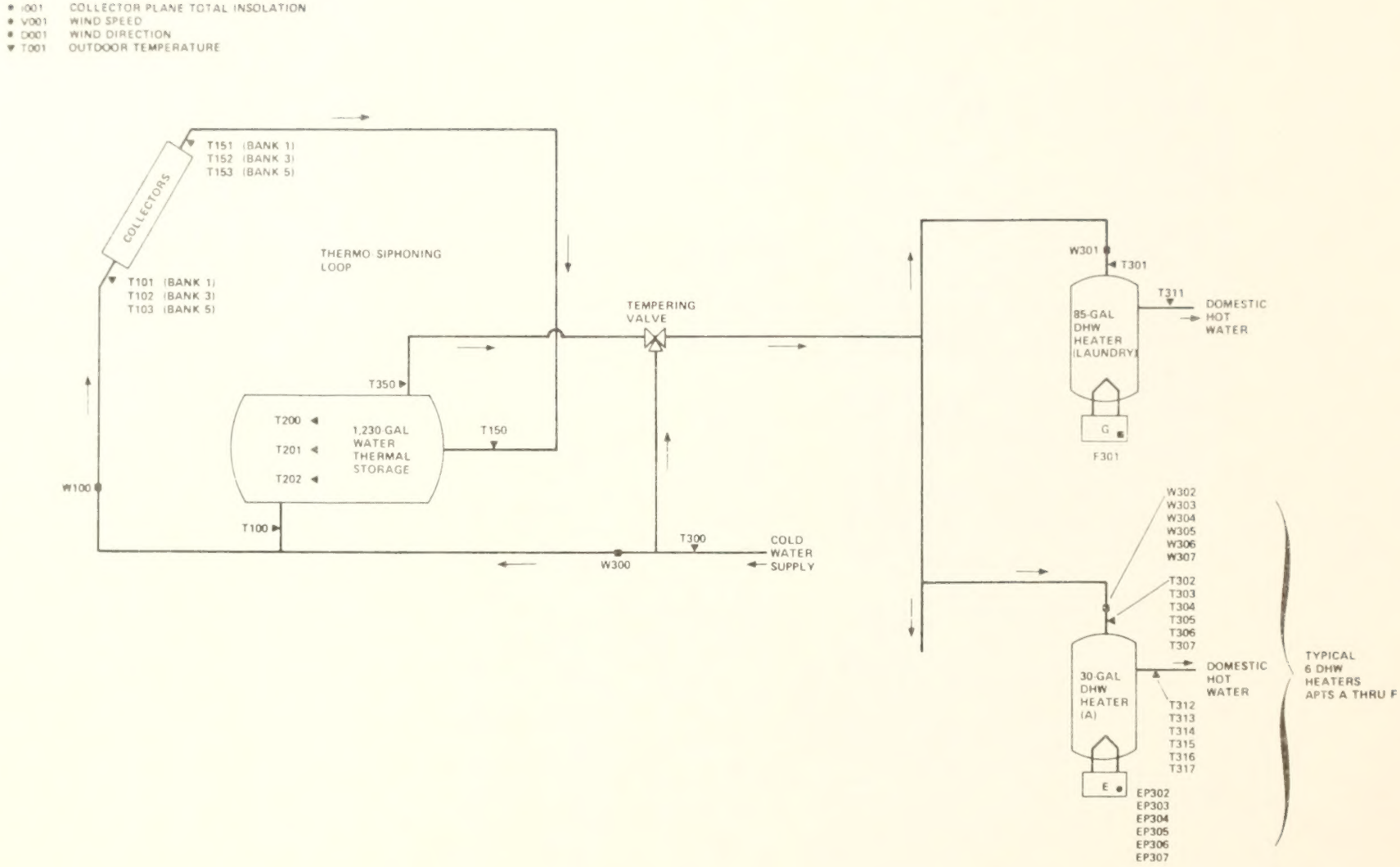

Figure 1. HEI WAI WONG SOLAR ENERGY SYSTEM SCHEMATIC

above the estimated average daily solar radiation for this geographical area during April of 1734 Btu per square foot for a south-facing plane with a tilt of 24 degrees to the horizontal. The average ambient temperature during April was 74°F as compared with the long-term average for April of 75°F.

THERMAL PERFORMANCE

System - During April the solar energy system performed better than expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 23.0 million Btu versus an estimated 10.5 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 11.3 million Btu. System total solar fraction was 94 percent versus an estimated 87 percent.

Collector - The total incident solar radiation on the collector array for the month of April was 46.9 million Btu. Since this is a thermosiphon operation, the insolation available during the period the collector loop was operating also amounted to 46.9 million Btu. The total collected solar energy for the month of April was 23.0 million Btu, resulting in a collector array efficiency of 49 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 23.0 million Btu. Since this is a thermosiphon operation, there were no operating energy requirements.

Storage - Solar energy delivered to storage was 23.0 million Btu. There were 11.3 million Btu delivered from storage to the DHW subsystem. Energy loss from storage was 11.7 million Btu. This loss represented 51 percent of the energy delivered to storage. The storage efficiency was 49 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 141°F.

DHW Load - The DHW subsystem consumed 11.3 million Btu of solar energy and 0.61 million Btu of auxiliary electrical energy and 0.15 million Btu of fossil fuel energy to satisfy a hot water load of 12.0 million Btu. The solar fraction of this load was 94 percent. There were no operating energy requirements. Solar support of the DHW subsystem in April resulted in an electrical energy savings of 8.6 million Btu and a fossil fuel energy savings of 4.5 million Btu. A daily average of 528 gallons of DHW was consumed at an average temperature of 159°F delivered from the storage tank.

OBSERVATIONS

The windspeed sensor malfunctioned. Since the derivation of wind direction is based in part on windspeed, the wind direction data was also invalid.

ENERGY SAVINGS

The solar energy system provided an electrical energy savings of 8.6 million Btu and a fossil fuel energy savings of 4.5 million Btu.

III. ACTION STATUS

Boeing plans to investigate the windspeed sensor operation during a June site visit.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/04
REPORT PERIOD: APRIL,1979

SITE/SYSTEM DESCRIPTION:
THE INSTRUMENTED SOLAR ENERGY SYSTEM AT HEI WAI WONG PROVIDES FOR PREHEATING OF DOMESTIC HOT WATER FOR 6 APARTMENT UNITS AND LAUNDRY SERVICE HOT WATER FOR THE 4 STORY APARTMENT COMPLEX.
WATER STORAGE IS LOCATED HIGHER THAN THE SOLAR COLLECTORS. THIS ALLOWS FOR WATER PRESSURE AND THERMOSIPHONING TO TRANSPORT THE WATER THROUGH THE COLLECTOR/STORAGE CIRCUIT. HOT WATER (DHW AND LAUNDRY SERVICE HW) FLOW TO THE BUILDING IS GRAVITY FED FROM THE ROOFTOP MOUNTED STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	46.875	MILLION BTU
	58057	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	22.957	MILLION BTU
	28433	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	74	DEGREES F
AVERAGE BUILDING TEMPERATURE	N.A.	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.24	
ECSS OPERATING ENERGY	N.A.	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	N.A.	MILLION BTU
TOTAL ENERGY CONSUMED	23.716	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	12.016	N.A.	N.A.	12.016	MILLION BTU
SOLAR FRACTION	94	N.A.	N.A.	94	PERCENT
SOLAR ENERGY USED	11.315	N.A.	N.A.	11.315	MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A.	MILLION BTU
AUX. THERMAL ENERGY	0.701	N.A.	N.A.	0.701	MILLION BTU
AUX. ELECTRIC FUEL	0.614	N.A.	N.A.	0.614	MILLION BTU
AUX. FOSSIL FUEL	0.145	N.A.	N.A.	0.145	MILLION BTU
ELECTRICAL SAVINGS	8.608	N.A.	N.A.	8.608	MILLION BTU
FOSSIL SAVINGS	4.512	N.A.	N.A.	4.512	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 5.487

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: APRIL,1979

SOLAR/1014-79/04

SITE/SYSTEM DESCRIPTION:
THE INSTRUMENTED SOLAR ENERGY SYSTEM AT HEI WAI WONG PROVIDES FOR PREHEATING OF DOMESTIC HOT WATER FOR 6 APARTMENT UNITS AND LAUNDRY SERVICE HOT WATER FOR THE 4 STORY APARTMENT COMPLEX.
WATER STORAGE IS LOCATED HIGHER THAN THE SOLAR COLLECTORS. THIS ALLOWS FOR WATER PRESSURE AND THERMOSIPHONING TO TRANSPORT THE WATER THROUGH THE COLLECTOR/STORAGE CIRCUIT. HOT WATER (DHW AND LAUNDRY SERVICE HW) FLOW TO THE BUILDING IS GRAVITY FED FROM THE ROOFTOP MOUNTED STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	49.453 GIGA JOULES
	659293 KJ/SQ.M.
COLLECTED SOLAR ENERGY	24.219 GIGA JOULES
	322883 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	24 DEGREES C
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.24
ECSS OPERATING ENERGY	N.A. GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	N.A. GIGA JOULES
TOTAL ENERGY CONSUMED	25.020 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	12.677	N.A.	N.A.	12.577 GIGA JOULES
SOLAR FRACTION	94	N.A.	N.A.	94 PERCENT
SOLAR ENERGY USED	11.937	N.A.	N.A.	11.937 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. THERMAL ENG	0.740	N.A.	N.A.	0.740 GIGA JOULES
AUX. ELECTRIC FUEL	0.648	N.A.	N.A.	0.648 GIGA JOULES
AUX. FOSSIL FUEL	0.153	N.A.	N.A.	0.153 GIGA JOULES
ELECTRICAL SAVINGS	9.081	N.A.	N.A.	9.081 GIGA JOULES
FOSSIL SAVINGS	4.761	N.A.	N.A.	4.761 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 5.487

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REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/04
REPORT PERIOD: APRIL, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	1.868	75	0.487	N	N	N	0.261
2	1.879	75	0.484	O	O	O	0.258
3	1.690	75	0.344	T	T	T	0.203
4	1.858	74	0.332				0.179
5	1.654	74	0.489	A	A	A	0.296
6	1.818	73	0.276	P	P	P	0.152
7	1.731	72	0.372	P	P	P	0.215
8	1.654	74	0.557	L	L	L	0.337
9	1.802	74	0.374	I	I	I	0.207
10	1.294	74	0.468	C	C	C	0.362
11	1.666	75	0.269	A	A	A	0.161
12	1.281	76	0.375	B	B	B	0.292
13	1.636	76	0.252	L	L	L	0.154
14	1.407	75	0.338	E	E	E	0.240
15	1.728	75	0.383				0.222
16	1.305	76	0.365				0.280
17	1.687	77	0.338				0.200
18	1.595	77	0.262				0.164
19	1.677	75	0.449				0.268
20	1.647	75	0.322				0.195
21	1.326	76	0.336				0.253
22	1.630	76	0.418				0.257
23	1.506	75	0.431				0.286
24	1.447	74	0.297				0.205
25	1.790	73	0.339				0.189
26	1.331	72	0.317				0.238
27	1.201	73	0.440				0.367
28	0.591	71	0.426				0.721
29	1.726	73	0.342				0.198
30	1.449	74	0.435				0.300
SUM	45.875	-	11.315	N.A.	N.A.	N.A.	-
AVG	1.562	74	0.377	N.A.	N.A.	N.A.	0.241
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	1.868	1.868	0.670	79	0.358
2	1.879	1.879	0.809	79	0.431
3	1.690	1.690	0.819	78	0.485
4	1.858	1.858	0.997	77	0.537
5	1.654	1.654	0.766	77	0.463
6	1.818	1.818	0.903	77	0.497
7	1.731	1.731	0.867	75	0.501
8	1.654	1.654	0.695	77	0.420
9	1.802	1.802	0.922	79	0.512
10	1.294	1.294	0.686	82	0.530
11	1.666	1.666	0.861	82	0.517
12	1.281	1.281	0.455	81	0.355
13	1.636	1.636	0.663	82	0.405
14	1.407	1.407	0.605	80	0.430
15	1.728	1.728	0.853	81	0.493
16	1.305	1.305	0.477	77	0.365
17	1.687	1.687	0.730	81	0.433
18	1.595	1.595	0.659	84	0.413
19	1.677	1.677	0.854	82	0.509
20	1.647	1.647	0.723	81	0.439
21	1.326	1.326	0.590	83	0.445
22	1.630	1.630	0.697	82	0.428
23	1.506	1.506	0.857	80	0.569
24	1.447	1.447	0.958	81	0.662
25	1.790	1.790	1.116	79	0.624
26	1.331	1.331	0.812	79	0.610
27	1.201	1.201	0.829	78	0.691
28	0.591	0.591	0.488	75	0.826
29	1.726	1.726	0.860	79	0.498
30	1.449	1.449	0.735	79	0.507
SUM	46.875	46.875	22.957	-	-
AVG	1.562	1.552	0.765	80	0.490
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.670	0.487	0.051	137	0.804
2	0.809	0.484	0.037	145	0.644
3	0.819	0.344	0.011	147	0.433
4	0.997	0.332	0.002	148	0.335
5	0.766	0.489	-0.036	146	0.591
6	0.903	0.276	0.014	144	0.320
7	0.867	0.372	-0.011	142	0.416
8	0.695	0.557	-0.079	138	0.687
9	0.922	0.374	0.075	139	0.486
10	0.686	0.468	-0.067	137	0.585
11	0.861	0.269	0.099	141	0.427
12	0.455	0.375	-0.046	142	0.721
13	0.663	0.252	0.042	144	0.444
14	0.605	0.338	0.057	144	0.652
15	0.853	0.383	-0.014	148	0.433
16	0.477	0.365	-0.092	142	0.574
17	0.730	0.338	0.058	144	0.542
18	0.659	0.262	0.108	151	0.562
19	0.854	0.449	-0.068	154	0.446
20	0.723	0.322	-0.018	150	0.420
21	0.590	0.336	-0.052	146	0.480
22	0.697	0.418	0.019	142	0.627
23	0.857	0.431	-0.071	141	0.420
24	0.958	0.297	0.043	140	0.355
25	1.116	0.339	0.053	146	0.351
26	0.812	0.317	-0.102	144	0.264
27	0.829	0.440	-0.076	134	0.439
28	0.488	0.426	-0.247	112	0.366
29	0.860	0.342	0.242	113	0.678
30	0.735	0.435	-0.018	129	0.567
SUM	22.957	11.315	-0.088	-	-
AVG	0.765	0.377	-0.003	141	0.489
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: APRIL,1979

SOLAR/1014-79/04

DAY OF MO.	HOT WATER LOAD MILLION BTU	SOLAR FR.CT LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.508	96	0.487	N	0.021	0.021	0.000	0.368	0.198	74	155	716
2	0.507	96	0.484	O	0.018	0.018	0.000	0.322	0.270	76	162	620
3	0.363	95	0.344	T	0.020	0.020	0.000	0.285	0.098	77	164	459
4	0.353	94	0.332		0.021	0.021	0.000	0.295	0.062	78	165	417
5	0.505	96	0.489	A	0.019	0.019	0.000	0.241	0.413	77	166	633
6	0.293	94	0.276	P	0.017	0.017	0.000	0.236	0.065	79	164	348
7	0.388	96	0.372	P	0.016	0.016	0.000	0.372	0.000	75	161	505
8	0.581	96	0.557	L	0.024	0.024	0.000	0.250	0.510	75	156	792
9	0.397	94	0.374	I	0.024	0.024	0.000	0.297	0.128	75	156	519
10	0.489	96	0.468	C	0.021	0.021	0.000	0.381	0.144	76	160	640
11	0.290	93	0.269	A	0.021	0.021	0.000	0.203	0.110	76	158	371
12	0.396	95	0.375	B	0.021	0.021	0.000	0.290	0.141	77	159	526
13	0.270	93	0.252	L	0.018	0.018	0.000	0.252	0.000	79	160	347
14	0.368	92	0.338	E	0.030	0.019	0.018	0.252	0.143	80	160	471
15	0.402	95	0.383		0.019	0.019	0.000	0.292	0.153	79	160	529
16	0.388	94	0.365		0.022	0.022	0.000	0.275	0.151	79	162	487
17	0.357	95	0.338		0.018	0.018	0.000	0.270	0.114	78	161	454
18	0.289	91	0.262		0.027	0.016	0.018	0.224	0.063	78	167	329
19	0.468	96	0.449		0.019	0.019	0.000	0.427	0.036	77	170	545
20	0.341	94	0.322		0.020	0.020	0.000	0.240	0.136	82	169	391
21	0.362	93	0.336		0.026	0.016	0.018	0.281	0.091	78	166	435
22	0.452	93	0.418		0.033	0.033	0.018	0.273	0.243	79	158	505
23	0.451	96	0.431		0.020	0.020	0.000	0.400	0.052	76	156	601
24	0.315	94	0.297		0.018	0.018	0.000	0.149	0.247	76	159	407
25	0.363	93	0.339		0.024	0.024	0.000	0.302	0.061	77	164	440
26	0.338	94	0.317		0.021	0.021	0.000	0.179	0.231	76	163	425
27	0.474	93	0.440		0.034	0.023	0.018	0.251	0.315	74	154	640
28	0.459	93	0.426		0.033	0.022	0.018	0.307	0.199	72	138	784
29	0.393	87	0.342		0.051	0.027	0.039	0.260	0.137	72	129	724
30	0.458	95	0.435		0.023	0.023	0.000	0.435	0.000	74	145	679
SUM	12.016	-	11.315	N.A.	0.701	0.614	0.145	8.608	4.512	-	-	15831
AVG	0.401	94	0.377	N.A.	0.023	0.020	0.005	0.287	0.150	77	159	528
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
Ø DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: APRIL, 1979

SOLAR/1014-79/04

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	2314	N	75	79	N	0	0
2	2327	O	75	79	O	0	0
3	2093	T	75	78	T	0	0
4	2302		74	77		0	0
5	2049	A	74	77	A	0	0
6	2252	P	73	77	P	0	0
7	2144	P	72	75	P	0	0
8	2048	L	74	77	L	0	0
9	2232	I	74	79	I	0	0
10	1603	C	74	82	C	0	0
11	2063	A	75	82	A	0	0
12	1587	B	76	81	B	0	0
13	2026	L	76	82	L	0	0
14	1743	E	75	80	E	0	0
15	2141		75	81		0	0
16	1617		76	77		0	0
17	2090		77	81		0	0
18	1975		77	84		0	0
19	2077		75	82		0	0
20	2040		75	81		0	0
21	1642		76	83		0	0
22	2019		76	82		0	0
23	1866		75	80		0	0
24	1792		74	81		0	0
25	2217		73	79		0	0
26	1649		72	79		0	0
27	1487		73	78		0	0
28	732		71	75		0	0
29	2138		73	79		0	0
30	1795		74	79		0	0
SUM	58057	N.A.	-	-	-	-	-
AVG	1935	N.A.	74	80	N.A.	0	0
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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